APS Policy and Procedure for Control of Measuring and Test Equipment

Section where used:

This procedure shall be used by all APS technical groups utilizing calibrated monitoring and test equipment to meet APS deliverables.

Changes made in this revision:

- Procedure rewritten; original procedure was used during APS construction.

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POLICY

The APS shall determine what controls and measurements are to be undertaken and the monitoring and measurement devices needed to provide evidence of conformity of its deliverables.

APS has defined its deliverables as:

1. Properties of the x-ray beam, which is what we deliver to users.
2. Compliance with safe operating limits, which is a deliverable to our funding and regulatory agencies.

Where applicable, APS ensures that the measurements affecting the quality of its deliverables are arrived at by the use of properly calibrated and maintained test equipment**.**

PROCEDURE

1.0 INTRODUCTION

The APS calibration requirements for measuring and test equipment (M&TE) under *ISO9001-2000* flow from the two deliverables mentioned above.

Where necessary, the measuring and test equipment that require calibration shall meet the following requirements:

1. Be identified to the APS Calibration Coordinator, who will include it on the list in Appendix B.
2. Be calibrated or verified at specific intervals.
3. Be identified to enable the calibration status to be determined. Use ANL calibration labels available in the APS Stockroom:
   - ANL-332 for Calibration
   - ANL-341 for Calibrate before Use
4. Be safeguarded from adjustments that would invalidate the measurement result.
5. Be protected from damage and deterioration during handling, maintenance, and storage.

1.1 Purpose

To provide a reliable and efficient process for managing and calibrating APS measurement and test equipment that is compliant with Argonne National Laboratory procedure # LMS PROC-50 and mandated DOE Orders. To fulfill these requirements, all

calibrations performed on APS devices will be traceable to recognized international and national measurement standards, such as those of the National Institute of Standards and Technology (NIST); and when no such standards exist, the basis used for calibration or verification shall be recorded (e.g. Lab notebook).

1.2 Applicability

This procedure applies to APS technical groups, the APS QA Representatives, the APS Calibration Coordinator, and APS employees who require the calibration of their measurement and test equipment.

1.3 Reference Documents

- ANL LMS PROC-50
- Doe Order 414.1C
- APS QA Plan
- ISO 9001: 2000

2.0 STEP- BY-STEP PROCEDURE

A detailed step-by-step flowchart for the calibration process with clear roles and responsibilities is included in Figure 1.

2.1 Roles and Responsibilities

Responsible Person	Required Activities
PSC ESH/QA Coordinator	• Generate Management Assessment Schedule and ensure closure of corrective actions.
APS Calibration Coordinator	• Maintain an updated list of M&TE devices requiring calibration.
APS Group Leader/Designee or PI	• Identify M&TE items that require calibration. • Keep an updated list of M&TE items in their respective groups. • Ensure calibration requirements are met according to LMS PROC-50 and follow-up on any non-conformance reports. • Coordinate required activities with calibration supplier. • Ensure all relevant calibration procedures are reviewed and kept up-to-date. • Consider M&TE calibration for Management Assessment.
AES/ASD/XSD QARs	• Train Technical groups with calibration requirements. • Participate in Management Assessments and generate/follow-up on corrective actions and provide feedback to APS Management.

M&TE User	• Complete training requirements. • Coordinate required activities with calibration supplier. • Review and file calibration results records

2.2 Preparation-Pre-requisite Actions

All personnel who will perform M&TE calibrations are required to read the following documents prior to execution of this procedure:

- Control and Calibration of Measuring and Test Equipment - LMS PROC-50
- Managing APS Facility Procedures - AP&P 3.1.05 (ICMS# APS_1001409)

3.0 DOCUMENTS/ RECORDS CREATED BY THIS PROCEDURE

The documents/records listed below will be created in the execution of this procedure and must be retained as indicated.

Description of Document/Record (include ID number, if applicable)	Custodian	Storage Location and Medium	Retention Requirement
Completed documentation results from supplier	M&TE Owner	ICMS and the groups	6 Years
Completed ANL M&TE calibration Data Sheets ANL-741 or ANL-395	M&TE Owner	ICMS, and groups	6 years
Complete any non-conformance reports recorded on ANL-626	M&TE Owner	iCATCH, electronic	6 years
Updated calibration procedures	M&TE Owner	ICMS, electronic	6 years

The following minimum metadata is required in order for these documents to appear in the ICMS library folder titled 'Instrument Calibration Records':

- Document Type: Report
- Title: must contain the text 'Calibration Record'. It is also recommended that the equipment name, model, and serial number be included in the document title.

To retrieve these ICMS calibration record documents,

- click on the 'Browse Content' tab above the Argonne logo on any ICMS page,
- click on 'Library Folders' in the dropdown menu,
- click on 'Instrument Calibration Records' in the list of Library Folders, and
- click on the group that owns the document.

If your group is not on the list of Library Folders, contact the ICMS Administrator.

4.0 FEEDBACK AND IMPROVEMENT

If you are using this procedure and have comments or suggested improvements for it, please go to the APS Policies and Procedures Comment Form* to submit your input to a

Procedure Administrator. If you are reviewing this procedure in workflow, your input should be entered in the comment box when you approve or reject the procedure.

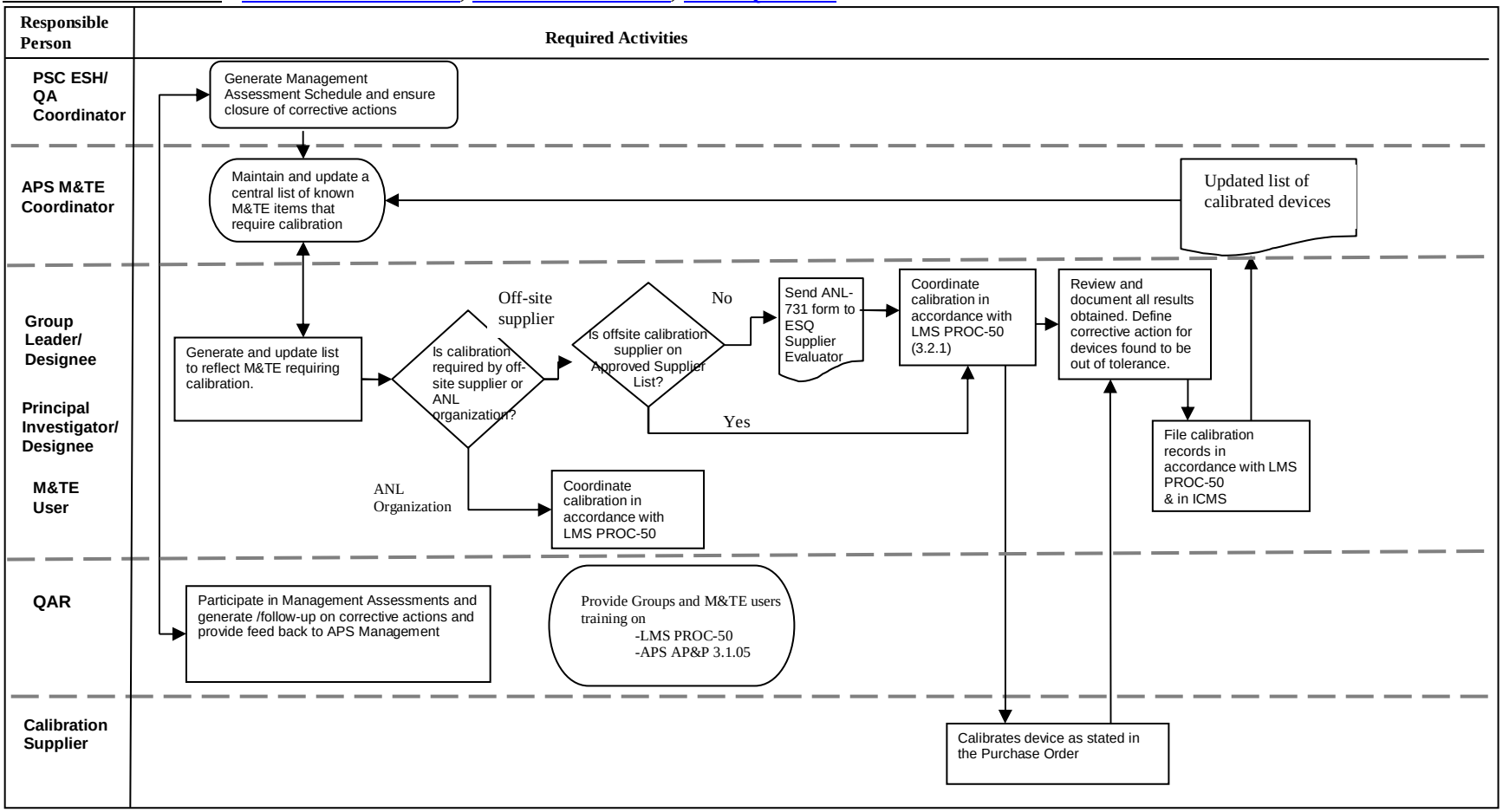
* http://www.aps.anl.gov/Internal/Policies_and_Procedures/comment_form.php

Figure 1-APS CALIBRATION PROCESS for M&TE 4-9-09

Purpose: To provide a reliable and efficient process for managing the calibration of APS mechanical test and measurement equipment that is compliant with ANL LMS PROC-50

Applicability: APS Technical Groups, APS QARs, and other APS employees who request the APS M&TE Coordinator to coordinate the calibration of their measurement and test equipment.

Reference documents: ANL LMS PROC-50, DOE Order 414.1C, APS QA Plan



Appendix A - APS Deliverables

I. X-ray Properties

Those x-ray properties under APS control are determined by the stored beam current, the stored beam energy, the bunch spacing, the beam size and divergence, and the insertion device in use at a particular beamline. The beam stability (in terms of centroid position and pointing angle) is also an important deliverable.

Deliverable	Calibration Requirement	Calibration Procedure
Stored Beam Current	Beam current is determined by the DCCT (Direct Current-Current Transformer). An accuracy of 1% is required.	APS_1284261
Stored Beam Energy	The stored electron beam energy is not directly measured, but is instead determined by the strength of the dipole magnets, which is directly measured using a reference magnet with an NMR (Nuclear Magnetic Resonance) probe. The required accuracy of the energy determination is 2.5%. Variation of 2% from the nominal energy is possible due to adjustment of the rf frequency and uncertainty in the magnetic length of the dipole magnets. According to the manufacturer, the NMR is accurate to 5 ppm and drifts by ±2 ppm/year; hence it does not require calibration within the life of the APS.	Not required
Bunch Spacing	Bunch spacing is an integral multiple of the rf period, which is determined by the frequency of the storage ring rf system. The required accuracy of the bunch spacing is 1%, which implies a 1% accuracy requirement for the ring rf frequency.	Not required
Beam Size & Divergence	Beam size and divergence naturally vary for different x-ray source points in the storage ring, as well as varying in time. Values for individual x-ray source points are inferred from the accelerator model and measurements at a reference	LOCO method for calibration (in progress) APS_1284034

	location. The required accuracy of the beam size and divergence measurements is 20% in the horizontal plane. In the vertical plane, the beam may have up to twice the size and divergence stated. The accelerator model is calibrated using the LOCO (Linear Optics from Closed Orbits) method, which has an accuracy requirement of 5% for $\sqrt{\beta}$. A technical document is in preparation describing how this accuracy is ensured. Beam size and divergence measurements at the reference location rely on measurements from the x-ray pinhole camera and the accelerator model. Reference location size and divergence measurements must be accurate to 15% to support the 20% requirement for beam size and divergence inferred at other locations. A technical note APS_1284034 describes the calibrations required to support this accuracy.	
Beam Stability	Beam stability measurements are specified in microns for specified frequency bands in the horizontal and vertical planes. An accuracy of 10% is required. The measurements make use of beam position monitors, which are calibrated at the 5% level by the lattice calibration software (see above).	
Insertion Device Properties	Several properties of each insertion device (ID) are relevant to the x-ray properties, namely, the ID period, field strength as a function of an accurately reproducible measurement of the gap, length (number of periods), and the undulator magnetic field phase errors. The number of periods (an integer or half-integer) is set during fabrication. The period length is also determined by the fabrication of the magnetic structure and confirmed by QA during fabrication	Gauge Block Calibration

	(outside of APS), using a coordinate measurement machine. The field strength varies with the ID gap and is typically adjusted by the users (experimenters) to suit their requirements. The user gets the readback from encoders as a report of the gap, and the relationship between the encoder readings and the magnetic field strength is measured during the ID magnetic tuning and is available online within the ID control system. The mechanical reproducibility of the gap has its origin in a set of ceramic gauge blocks that serve as an internal calibration standard. The quality of the undulator magnetic field—the smallness of the magnetic field phase errors—helps determine the brilliance of the photon beams created in the undulators. Calibration of the magnetic field probe is good to better than 100 ppm, which is more than adequate. The calibration is with respect to an NMR teslameter. According to the manufacturer, the NMR is accurate to 5 ppm and drifts by ±2 ppm/year; hence it does not require calibration within the lifetime of the APS.	

II. Compliance with Safe Operating Limits

Compliance with safe operating limits refers to the following:

1. Operation within the accelerator safety envelope.
2. Proper operation of radiation limiting interlocks.
3. Proper operation of collimators, beam stops, x-ray absorbers, and shutters
4. Beam current and energy above minimum allowed values during top-up operation.

In this context, when we refer to proper operation of interlock systems, we do not refer to testing to verify interlock logic or wiring. Rather, we refer to verification that interlock systems use sufficiently accurate measurements of relevant physical quantities.

Deliverable	Calibration Requirement	Calibration Procedure
Safety Envelope Enforcement	The safety envelopes are expressed in terms of allowed average beam current through various current sensing devices. The trip levels for these devices are validated periodically or following certain maintenance activities using calibrated references. These validations are covered by APS procedure # 210603-00012 (APS_1192873) and APS procedure # 21060201-00035 (APS_1283821), which reflect a revised approach, namely, that the trip points are set 10% or more below the desired maximum current. Required calibration accuracy for the trip points is thus 10%.	APS Procedure # 210603-00012 (APS_1192873) APS Procedure # 21060201-00035 (APS_1283821)
Radiation Limiting Interlocks	Radiation outside the shield wall is sensed and limited by a number of radiation monitors around the facility. These are calibrated periodically using a check source. The strength of the check source must be calibrated to an accuracy of 15%. ESQ-RSO maintains and periodically calibrates these monitors. ESQ-RSO is responsible for affixing calibration stickers to the monitors and maintaining calibration documents and records.	Maintained by ESQ-RSO
Collimators, Beam Stops, X-Ray Absorbers, and Shutters	Collimators, beam stops. X-ray absorbers and shutters are fixed and movable devices that are used to prevent electron and x-ray beams from entering areas where their presence could create a hazard. The dimensions of a collimator, beam stop, absorber, or shutter and its position, when inserted, determine whether it will perform the desired function. Dimensions that are critical to safety are verified to be within tolerances by QA processes per APS procedure # 1110-00198 (APS_1282405), the AES Radiation Safety System inspection procedure. Positioning of these components, when	APS Procedure # 1110-00198 (APS_1282405) APS Procedure # 53-00001 (APS_1200799) APS Procedure # 310301-00411 (APS_1194658) APS Procedure # 3-00055 (APS_1193979)

	installed, is assured to be within tolerances by alignment per APS procedure # 53-00001 (APS_1200799). Calibration requirements for the instruments used are stated in the inspection records for these components. In addition, X-ray absorbers serve as electron beam apertures that limit beam excursions, thus ensuring top-up can be safely performed. The final location of absorbers in the storage ring chambers is determined by the design of the chambers and the absorber assemblies. The chambers are then positioned via fiducials, surveyed by S&A to the correct position. Positions of storage ring vacuum chambers in the magnets are verified using APS procedure # 310301-00411 (APS_1194658). This procedure does use go/no-go gauges to verify that the chambers are within ±2 mm relative to the quadrupoles and sextupoles. This is done during every maintenance period to ensure that SR apertures are safe for machine operation in top-up mode. The tolerance budget associated with positioning of storage ring chambers and magnets for top-up safety are given in APS procedure # 3-00055 (APS_1193979).	
Top-up Interlocks	Top-up operation cannot be performed unless there is stored beam, nor can it be performed at energies below 6 GeV. The former requirement is enforced by the top-up stored beam monitor, which is periodically validated according to APS procedure # 3105-00010 (APS_1191883); no calibration is required. The 6-GeV requirement is enforced by voltage and current interlocks on the storage ring dipole power supply. These are calibrated to the required 1% level per APS	APS Procedure # 3105-00010 (APS_1191883) APS Procedure # 31020101-00027 (APS_1192186) APS Procedure #31050401-00040 (APS_1284261)

	procedure # 31020101-00027 (APS_1192186) for a precision meter and procedure # 31050401-00040 (APS_1284261) for the current transducer electronics.	

Appendix B - List of Measuring and Test Items Requiring Calibration

Please see APS_1285392 for the APS FY09 Calibration List.